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The Deep Imprint of Roman Sandals: Evidence of Long-lasting Effects of Roman Rule on Personality, Economic Performance, and Well-Being in Germany

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Abstract

We investigate whether the Roman presence in the southern part of Germany nearly 2,000 years ago had a deep imprinting effect with long run consequences on a broad spectrum of measures ranging from present-day personality profiles to a number of socioeconomic outcomes and why. Today's populations living in the former Roman part of Germany score indeed higher on certain personality traits, have higher life and health satisfaction, longer life expectancy, generate more inventions and behave in a more entrepreneurial way. These findings help explain that regions under Roman rule have higher present-day levels of economic development in terms of GDP per capita. The effects hold when controlling for other potential historical influences. When addressing potential channels of a long term effect of Roman rule the data indicates that the Roman road network plays an important role as a mechanism in the imprinting that is still perceptible today.

Keywords: Romans, personality traits, culture, well-being, regional performance, Limes

JEL codes: N9, O1, I31

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1. Introduction[1]

With the growing body of evidence indicating that history affects economic outcomes (e.g., Alesina and Giuliano 2015; Guiso, Sapienza and Zingales 2006), scholars have begun to apply a cultural lens for a better understanding of how historical processes lead to present-day economic outcomes (Diamond and Robinson 2010; Nunn 2009, 2012). These studies indicate that influential historical processes shaping local culture can reach far back in time (Boyd and Richerson 2005)—possibly centuries or millennia ago—with a potentially very deep and persisting imprinting effect that is still detectable in attitudes, values, personality traits, and behaviors of today's regional population.[2] Some authors even claim that a number of important ingredients in the present European culture can be traced back to ancient Egypt, centuries before the emergence of Christianity (Assmann 2018; Winkler 2009). It is therefore important to better understand these influential historical events, their long lasting imprint on culture shaping socioeconomic outcomes, and underlying mechanisms.

This study analyzes long lasting effects and potential underlying mechanisms of the occupation of certain parts of Germany by the Roman Empire about 1,700 years ago. While there is initial evidence that those regions that once belonged to the former Roman part of Germany are today economically more wealthy (e.g., Wahl 2017), underlying mechanisms and in particular the role of imprinting effects on present-day culture are still unclear. By following calls to go beyond the conventional but criticized GDP approach to assess regional outcomes (Fleurbaey 2009; Jones and Klenow 2016; Porter et al. 2014), we try to understand the fuller range of regional outcomes that together might go back to the Roman imprint. We thus analyze a broad spectrum of indicators representing present-day personality profiles (as a psychological indicator of culture), life and health satisfaction and life expectancy of the regional population as well as innovation behavior and levels of entrepreneurship. We assume that the Romans left a deep imprinting effect that shaped regions in several respects and can still be

[1] We are indebted to Giacomo di Luca, Andy Pickering, Korneliusz Pylak and Michael Stuetzer for helpful comments and suggestions on an earlier draft.

[2] E.g., Bazzi et al. (2017), Buggle and Durante (2017), Giuliano and Nunn (2013), Lowes et al. (2017), Schulz et al. (2019).

identified in the personality traits of the local population and in measures for socioeconomic performance.

Of particular interest for our study is the Roman Limes—the border that once separated the Roman Empire from the ´German Barbarians´ in the North. We test whether the assumed imprinting effect of the Romans is indeed particularly deep in a sense that it not only predicts a broad range of outcomes at the same time, but that it also better forecasts these outcomes than other major historical events that could also be regarded as constitutional in the German history[3]. In doing so, our study contributes to the growing literature on historical roots of psychological well-being and economic performance.[4] The paper also builds on, and helps to explain the evidence indicating that Roman legacy may have had a positive effect on current economic development.[5]

We find that today's population in the former Roman territories of Germany have on average a personality profile characterized by higher levels of conscientiousness and lower levels of neuroticism, by higher levels in extraversion and an intraindividual entrepreneurial personality profile. According to personality research at both the individual and regional level (e.g., Barrick and Mount 1991; Bogg and Roberts 2004; Costa and McCrae 1980; Garretsen et al. 2018; Judge and Ilies 2002; Obschonka et al. 2015; Stuetzer et al. 2018), such personality characteristics are typically associated with higher levels of psychological well-being and economic performance. Indeed, we find that German regions with a Roman legacy show higher levels of life and health satisfaction, longer life expectancy, generate more innovations and behave in a more entrepreneurial way (see Figures A1 to A3 in the Appendix). According to our results, such a Roman imprinting effect can be also found when looking at historical outcomes for commercial activity and education in the late Middle Ages.

[3] E.g., influential trade coorporations such as the Hanseatic League, massive cultural and socioeconomic shocks such as medieval plagues, or the effect of Napoleonic occupation.

[4] E.g., Abdellaoui et al. (2019), Nunn (2012), Obschonka et al. (2017, 2018), Talhelm et al. (2014), Schulz et al. (2019), Stuetzer et al. (2016), Fritsch et al. (2019).

[5] See, for example, Wahl (2017) or Flückiger et al. (2019).

The long lasting effect of Roman rule, as indicated by our results, is rather remarkable given the many disruptive shocks and the high levels of the population's geographic mobility over this long time period. One way to interpret our empirical evidence is that there is something 'in the air', as Alfred Marshall has put it, that shapes socioeconomic outcomes in regions and that it is 'places not people' that affect regional development (Guiso, Sapienza and Zingales 2006). The specific coherent set of personality structure, subjective well-being, health conditions and economic performance in the former Roman territory, might altogether form the 'something in the air' in these regions today. Hence, we see indications of a Roman effect on exactly those traits that are known to shape these beneficial regional outcomes.

To understand possible historical channels through which Roman influence could have persisted until today, we investigate whether the Roman effect is attributable to two measures of Roman presence, the density of Roman roads and the number of Roman markets and mines. The first measure proxies for the frequency of interregional social and economic interactions and mobility. These can influence attitudes of people towards strangers, risk aversion, and openness towards change and thereby personality profiles that are conducive for the development of 'entrepreneurial culture' and an environment that is economically rewarding for creativity and innovativeness. Indeed, we find that socioeconomic outcomes, but to some extent also the personality traits, are explained by regional Roman road density. In contrast, the results for the numbers of Roman markets and mines that indicate levels of economic activity are much weaker. However, selective migration and a genetic component might also be responsible for the observed reduced form relationships between personality traits and Roman legacies.

The remainder of the paper is organized as follows. Section 2 provides an overview of related literature. Section 3 describes the Limes and Roman occupation in some more detail while Section 4 introduces data and definitions. Section 5 presents the results of the empirical investigation. The final section (Section 6) concludes.

2. Previous research

2.1 Imprinting effect of Roman rule

In a recent study, Wahl (2017) investigated the relationship between the Roman Limes in Germany and regional economic development as measured by night light luminosity about 100 km north and south of the Limes. The study could convincingly show that regions in the former Roman part have significantly (at least 10 %) higher luminosity than those north of the Limes. Wahl (2017) also demonstrated that the Roman road network is remarkably persistent until today, as, for example, around 87 % of the contemporary highways in the Roman parts of Germany are located within 10 km of a Roman road. Wahl (2017) and others (e.g., Flückiger et al. 2019) argue, that Roman roads lowered transport costs, fostered city growth and influenced the location of new cities founded during the Middle Ages. Wahl (2017) suggests that these long lasting consequences of the Roman roads could be regarded responsible for the ‘Roman development effect’ he discovered.

Closely related to this study, Dalgaard et al. (2019) investigate night light intensity around the location of all historical Roman roads and find that not only night light intensity, but also road density and density of historical settlements are notably and robustly larger around them. De Benedictis, Licio and Pinna (2018) calculate a measure of interregional trade costs for Italian provinces and show that the length of provincial Roman roads make a rather significant contribution to explaining these costs. All of these studies make use of the fact that, according to historical accounts and empirical tests, Roman roads follow an economically sub-optimal path. The reason may be that these roads were primarily built for military purposes (e.g., shifting troops from one location to another) without accounting for terrain characteristics such as elevation or slope—which would be important for the efficient transportation of goods with oxen or by foot. Therefore, the course and the location of Roman roads can be considered exogenous to Roman or pre-Roman economic patterns.

Michaels and Rauch (2017) came to a more nuanced conclusion about the effect of the Romans on subsequent developments. Investigating urbanization in Britain and France from the Roman Era until today, they found that the breakdown of the Western Roman Empire ended urbanization in Britain but not in

France. When urbanization started again in the medieval period, towns in France were often rebuilt or founded on old Roman town locations. In England, where Roman rule ended considerably earlier than in France, the urban network of Roman roads did not persist. Much later new towns emerged close to the coast or at navigable waterways. This has given these newly emerging cities a decisive advantage over their counterparts from the Roman period, as access to waterways became a decisive growth factor for cities only after the time of Roman occupation. Michaels and Rauch (2017) conclude that it was actually advantageous to be part of the Roman Empire but better for not too long. Given the specific geography of England as an island, access to navigable waterways and seaports may have been considerably more important for development as compared to France and Germany.

Flückiger et al. (2019) show that the Roman trade network across Europe as proxied by the regional prevalence of excavated Roman ceramics is still important for understanding cross regional investment behavior. More specifically, the authors document that interregional trade in Roman times was highly influenced by connectivity within the ancient transport network. They explain the long run persistence of that connectivity by a relatively high level of cultural integration in terms of converging values and preferences of the population that may be due to dense and repeated social and economic interactions between the well-connected parts of the network.

While the previous studies greatly enhanced our understanding of how Roman legacy affected economic development at large, the imprinting effects of Roman rule and the reasons behind a relationship with the broad well-being and performance indicators of today's populations that go beyond a simple focus on GDP, remain unclear. Such imprinting effects of historical processes can be reflected by personality traits of the local population (e.g., Talhelm et al. 2014; Stuetzer et al. 2016; Obschonka et al. 2018) but, even more importantly, they can also be reflected in "hard" socioeconomic outcomes of regions that are shaped, at least in part, by these regional personality traits (Rentfrow, Gosling and Potter 2008). For example, a culturally mediated historical imprinting effect could also be visible in terms of particular economic behaviors such as innovation and new business formation, which are typically growth enhancing (Aghion 2017; Fritsch and Wyrwich 2017). It has been shown that both innovation and new business formation, are significantly related to local cultural attitudes (Beugelsdijk 2007) that, in turn, can be proxied by the aggregate personality traits of the local population (Garretsen et al. 2018; Fritsch, Obschonka and Wyrwich 2019). Personality traits of the local population such as openness and conscientiousness are deemed important for regional entrepreneurship, innovative activity, and local economic development at large (Garretsen et al. 2018). Other research indicates that historical imprinting effects can also shape regional psychological well-being, health outcomes, and underlying corresponding personality characteristics that were also shaped by the same imprinting mechanism (e.g., Obschonka et al. 2018). Taken together, there is growing evidence indicating that a deep imprinting effect of a major historical event could have shaped the personality traits and profiles of today's local population as well as those 'hard' socioeconomic outcomes that go hand in hand with these personality characteristics.

However, there is a research gap with respect to the imprinting effects of Roman rule on personality traits and corresponding certain (growth promoting) economic behaviors. There is also a lack of understanding of the effects of Roman rule on the well-being of the local population, which can be captured by health, life satisfaction, and life expectancy as we discuss in the next section.

2.2 Personality traits, economic behavior, and well-being of the regional population

Recent advances in psychological research established that not only individuals but also regions differ in personality traits, with important implications for 'hard' regional outcomes that are also shaped by local personality characteristics (Rentfrow 2020; Rentfrow and Jokela 2016; see also Florida 2010). Hence, while personality traits are a major shaper of life outcomes at the individual level, research evidence from regional studies suggests that this also applies at the regional level, i.e., personality traits of the regional population have an effect on regional outcomes. This led to a new focus on regional personality in regional research interested in a variety of outcomes beyond GDP (Huggins and Thompson 2019; Rentfrow 2020).

Why are personality traits so influential? At the individual level, it is well-established that a person's personality traits shape a wide range of central life outcomes such as psychological well-being (e.g., happiness - Chamorro-Premuzic, Bennett and Furnham 2007; Steel and Ones 2002; Steel, Schmidt and Shultz 2008), health (Bogg and Roberts 2004; Friedman 2000), as well as motivations, achievements and performance in the occupational career (Barrick and Mount 1991; Judge and Ilies 2002). Personality researchers thus often emphasize “the power of personality” as a major determinant of a person’s life outcomes (Roberts et al. 2007). Simply put, personality traits like the Big Five (extraversion, conscientiousness, openness to new experience, agreeableness, neuroticism)[6], which show substantial (but not perfect) stability over the live course (Caspi 2000; Caspi, Roberts and Shiner 2005), influence the way people (a) experience and interpret the self and their environment, (b) are perceived and evaluated by others, (c) make central decisions in life, (d) are motivated to engage in certain behaviors, and (e) succeed in different behaviors (McCrae and Costa 2008). While the majority of personality research was traditionally focused on the single individual (Allport 1923), the field of geographical psychology (Rentfrow 2020; Oishi 2014) has begun studying regional differences in personality traits—the ‘personality of regions’ as a whole (Florida 2010). A growing body of research indicates that regions within countries show more or less systematic differences in the personality profile of their population (Oishi 2014; Obschonka et al. 2018; Rentfrow et al. 2008, Rentfrow, Jokela and Lamb 2015; Rentfrow 2020). By far less understood are the historical sources and mechanisms that led to such a differentiation in the psychology of regions.

The existing regional personality differences are not mere descriptive psychological features of regions but can have important real-world consequences for their performance and thus future trajectories. Studies of the effects of region specific personality traits suggest that regional personality differences correlate with, and may even contribute to, important regional outcomes such as well-being and health level of the population (Rentfrow et al. 2008, Rentfrow, Mellander and Florida 2009, Rentfrow et al. 2015; Obschonka et al. 2018) as well as regional economic performance and vitality (Garretsen et al. 2018; Obschonka et al. 2015, 2016, Steel, Rinne and Fairweather 2012), Stuetzer et al. 2016, 2018). There are at least two basic mechanisms though which regional personality differences can

[6] The Big Five is the leading, best researched and validated personality model (Goldberg 1990; McCrae and Costa 2008).

shape the regional culture and socioeconomic outcomes (Rentfrow et al. 2008). First, more individuals in a regions with a certain personality structure that makes a certain outcome more likely at the individual level can also lead to corresponding regional outcomes.[7] Second, pure region level factors such as a certain psychological climate that is “in the air” (Marshall 1920) could be at work. Via peer and role model effects, such a psychological climate could stimulate corresponding behavior of people in the region that do not show such personality traits themselves.[8]

Previous research indicates that regional differences of personality traits of the local population may show considerable degrees of stability and persistence over time (Elleman et al. 2018; Plaut et al. 2012; see also Rentfrow et al. 2008). These relatively stable regional personality differences, in turn, might contribute to (and interact with) the often observed regional persistence in local economic performance (Acemoglu and Robinson 2012; Fritsch, Obschonka and Wyrwich 2019). Hence, inspired by a trait perspective to culture (McCrae 2001, 2004 Hofstede and McCrae 2004), researchers have begun to understand region specific personality traits as components of the local culture that might have evolved and persisted over longer periods of time (Fritsch et al. 2019; Stuetzer et al. 2016). This links the psychological research on regional personality differences to the vast literature on culture that shapes important regional outcomes (Diamond and Robinson 2010; Guiso et al. 2006; Huggins and Thompson 2019; Nunn 2009, 2012).

With respect to the origins of regional personality differences, Rentfrow et al. (2008) presented a theory that emphasizes selective historical migration patterns (e.g., genetic founder effects) as well as socialization mechanisms via local institutions that together influence the emergence and persistence of regional personality differences (see also Oishi 2014). A growing number of studies is addressing these potential historical mechanisms, for example with a focus on the

[7] E.g., more people with an entrepreneurial personality can lead to higher propensities in these people to act entrepreneurially, which in turn can get manifested via increased entrepreneurship rates in the region

[8] E.g., more people with an entrepreneurial personality could lead to stronger, collective entrepreneurial climate effects that also motivate people who have a less pronounced entrepreneurial personality to engage in entrepreneurship.

Industrial Revolution (Obschonka et al. 2018) or selective migration patterns (Abdellaoui et al. 2019). Hence, existing studies could already find effects of historical events on present-day regional personality traits over periods of up to 200 years.[9] It is, however, an open general question whether historical factors can shape personality characteristics for a time period of nearly two thousand years that is characterized by numerous disruptive developments and particularly high mobility of the population. Could it be the case, for Germany, that Roman rule had a long term, constituting impact on the mentality of today's regional population? And if this is true and if the local mentality shapes a whole variety of "hard" regional outcomes, are there also implications of this historical imprint on the type of (growth promoting) economic activities and psychological well-being and health prevalent among the population?

Taken together, the new literature on regional personality differences, its effects on a broad range of regional outcomes and associated developmental trajectories (including imprinting effects) strongly suggests to study and understand such regional personality differences in a broad approach goes beyond measuring regional performance with GDP. As a consequence our analysis focuses on various regional socioeconomic outcomes that also include population well-being (e.g., Obschonka et al. 2018).

2.3 Did the Romans leave an imprint on personality traits, economic behavior, and well-being?

The present study works under the assumption that Roman rule left an enduring, deep imprint in the respective German regions south of the old Roman border wall, the Limes. And this deep imprint might not only be visible in regional differences in the level of economic activity (Wahl 2017) and GDP today, but much deeper, in the local personality structure, and thus the regional culture, as well as socioeconomic outcomes of these regions. This would mean that the Romans could have left a more influential and far-reaching imprint in these regions than previously thought.

[9] Abdellaoui et al. (2019), Fritsch, Obschonka and Wyrwich (2019), Talhelm et al. (2014), Obschonka et al. (2018), Plaut et al. (2012), Stuetzer et al. (2016).

A main reason for such a relationship between Roman occupation nearly 2,000 years ago, personality traits of today's population and current socioeconomic outcomes could be the road system that the Romans built. It has been shown for a number of countries that Roman roads had long lasting effects by shaping the traffic infrastructure and urbanization patterns to today (Wahl 2017; Dalgaard et al. 2018). This had an influence on the level of interregional mobility and the geography of social and economic interactions. Higher levels of mobility and interregional interactions could very likely affect the attitudes of the population important for entrepreneurial activity, such as the attitude towards strangers, the level of risk aversion and tolerance towards change as well as its openness for new ideas. This corresponds to the reasoning by Flückiger et al. (2019) who show that highly integrated and interconnected regions in the Roman trade network continue to have more intensive economic linkages today and higher cross regional investments of firms. These authors argue that this persistence comes from cultural integration achieved by convergence of preferences and values between the populations of the highly interconnected regions. We therefore expect that the density of Roman roads could be responsible for a persistent effect of the Romans on personality traits.

A second reason to expect a relationship between Roman legacy, current personality traits and socioeconomic outcomes builds on the presence of Roman markets and mines. Such centers of economic activity might have been characterized by pronounced incentives for creativity and innovativeness and may, therefore, have attracted people with such traits to these places. High levels of economic activity may have particularly contributed to the emergence and persistence of a local culture of entrepreneurship that is also partly captured by the personality profile of the local population (Fritsch et al. 2019) persisting until today due to selective migration on the one hand and persistence of economic activity since Roman times on the other. Furthermore, research showed a genetic pathway, and associated migration patterns, contributed to today's regional personality differences and corresponding regional disparities in health, economic, and cultural outcomes (Abdellaoui et al. 2019).

Historical research (Badian 1980, 1997 and Löffl 2014) supports the idea of an alternative channel namely that a pronounced entrepreneurial culture in the areas that were ruled by the Romans could have given these regions a headstart in entrepreneurship and economic activity that persists until today. An important argument of this line of thought is that from its beginning the Roman state outsourced genuinely public tasks in order to limit the size of the administration. In the Empire period (31 BC – AD 476), some state tasks were executed by the army but many were done by private entrepreneurs, most importantly, tax collection. Therefore, an “entrepreneurial mindset” and a belief in the ability of the private economic sector to be efficient seem to have existed during the Roman era.

This is well in line with previous research showing that the prevalence of a local entrepreneurial culture is a crucial source for persistence of entrepreneurship despite several historical shocks.[10] This evidence also suggests that there is a collective memory of successful entrepreneurial activity in the past that led people to consider entrepreneurship as a viable economic activity and has resulted in an entrepreneurial culture that is ‘in the air’ (Marshall 1920) and can survive rather hostile socioeconomic framework conditions for longer periods of time. What is particularly remarkable is that empirical studies show that such a culture or collective memory that shapes the behavior of population is regionally bounded (e.g., Fritsch, Obschonka and Wyrwich 2019; Stuetzer et al. 2016). Hence, history may create invisible borders.

Finally, there should be also a relationship between Roman legacy and life satisfaction, health, as well as life expectancy. This idea is based on the assumption that well-being is typically positively correlated with the degree of economic development (Abdellaoui et al. 2019; Obschonka et al. 2018). Thus, given that the presence of the Romans was conducive to higher levels of economic development (e.g., Wahl 2017) and assuming that, at the regional level, there may also be an effect of Roman rule on well-being, finding long term imprinting effects would be in line with the considerable empirical evidence that points towards a long term persistence of attitudes, values and behaviors of a regional population (see Nunn 2009, 2012 for an overview).

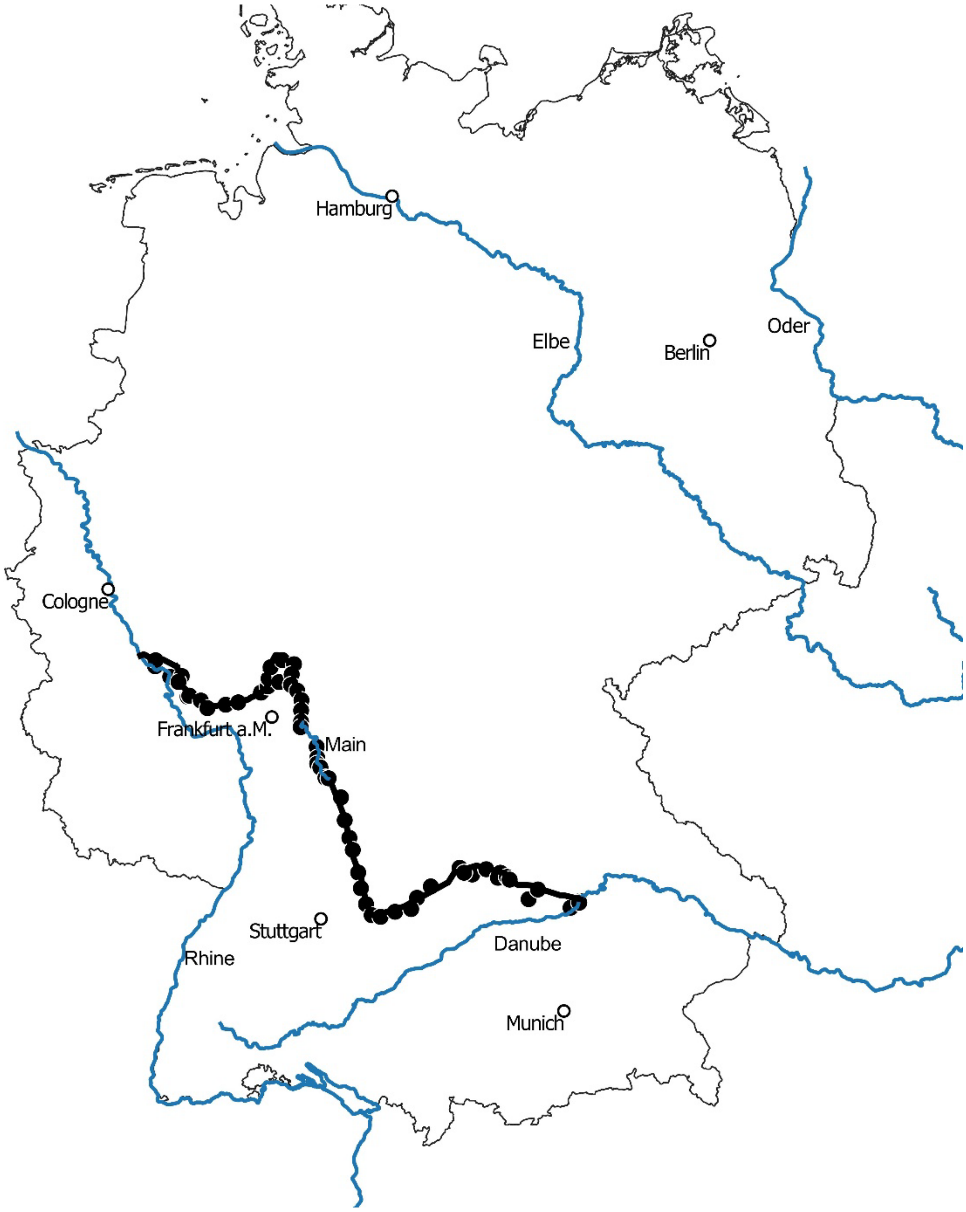
[10] E.g., Fritsch and Wyrwich (2014), Fritsch at al. (2019), Stuetzer et al. (2016), Huggins and Thompson (2019).

3. The historical Roman border through Germany

To address our basic question whether the former Roman border through Germany, the ‘Limes Germanicus’, indeed established a geographical “line of fate” that separates Germany until today, it is important to accurately locate this historical border line. Fortunately for our analysis, the Limes can be identified with quite some precision. It consisted of three major rivers, namely the Rhine, the Danube and the Main (‘Main Limes’) as well as a physical wall. This wall consisted of two parts, the Upper Germanic and the Rhaetian Limes, which were connected by the river Main. The walled parts of the border left physical traces like the remains of walls and towers, surviving ditches and forest aisles as well as hills with stone rubble at the location of watchtowers. Additionally, many Roman forts along the walled Upper Germanic and the Rhaetian Limes are helpful in identifying the course of the Roman border (Henrich 2012, 2014).[11]

The Limes wall connected the two border rivers of the Roman Empire in Germany, the Danube and the Rhine. The Romans built it around 150 AD and it acted as border of the Empire for more than 100 years. The Romans abandoned the Limes latest in 275/276 AD and retreated to positions west of the Rhine, south of the Danube and east of the river Iller. The Limes represents the border of the largest territory in Germany that the Romans were able to retain for a longer period of time. During these more than 100 years the Limes constituted not only of a physical but also an economic and cultural border between the Roman and the Germanic culture during the Roman period (Von Schnurbein 1995). There was, however, a rather significant amount of controlled trade between the Roman and the non-Roman areas. The Limes also marks the boundary of the Roman road network (according to McCormick et al. 2013). It should be noted that there were no significant roads in terms of constructed routes for travel on land north of the Limes in those times.

[11] Archeologists also found and reconstructed forts along the river parts of the border. However, as the location of the rivers is uncontroversial we will focus on the forts along the walled parts.



Note: The Limes Germanicus (Upper-Germanic and Rhaetian Limes) is the solid black line. Roman forts are shown as black dots. The borders are those of current German Federal States.

Figure 1: The Limes Germanicus in 200 AD, major rivers and cities, Federal States, and Roman forts

From the viewpoint of identifying a causal effect, it is important to note that the general course of the Limes was determined by the need to establish a safe connection between the two Roman provinces of Upper Germany and Rhaetia. Hence, the Limes tried to connect these two provinces by conquering the smallest territory necessary in order to avoid additional wars with the German barbarians. Its course reflects primarily military and strategic, not economic considerations. This reasoning is further supported by the fact that for around 80 kilometers, the Limes followed a straight line and was built without regard to the varied topographies of the area (Wahl 2017; Schallmayer 2011; Planck and Beck 1987).

Figure 1 shows the course of the Limes wall through Germany around the year 200 AD.[12] It also depicts the rivers Rhine, and Danube, as well as the parts of the river Main that constituted a part of the border. It also shows the location of Roman forts, which can be used to check the validity of the location of walled parts of the border (the Upper Germanic and Rhaetian Limes), as well as some contemporary large cities.

4. Data and empirical approach

4.1 Data

4.1.1 Historical and geographical data

The spatial framework of our analysis are planning regions (*Raumordnungsregionen*) that represent functionally integrated spatial units comparable to labor-market areas in the United States. There are 96 German planning regions.[13] We overlay shapefiles of the walled Limes parts, and the courses of Danube, Rhine and Main, with one on the borders of the planning regions. In doing so, we are able to assign the planning regions to the historical Roman area. We are also able to identify regions that are split by the Roman border, i.e., located partly within the Roman Empire and partly in the non-Roman area. We create a dummy variable equal to one (and zero otherwise) for such 'split regions'. They could be special as they are partly treated and partly not.

[12] Based on a shapfile of European borders from the Digital Atlas of Roman and Medieval Civilizations (DARMC) by McCormick et al. (2013), which is the digital version of Talbert's (2000) atlas.The DARMC can be accessed at http://darmc.harvard.edu/icb/icb.do?keyword=k40248&pageid=icb.page188865. Regarding Roman roads, we limit ourselves to roads that are classified by Talbert to be certain and major. We do not show the location of earlier border walls like the 'Odenwald Limes'.

[13] Shapefiles for the borders of the planning regions are from the Federal Institute of Research on Building, Urban Affairs and Spatial Development (Bundesinstitut für Bau-, und Stadt- und Raumforschung, BBSR). They are freely available at https://stern.carto.com/tables/shapefile_raumordnungsregionen_nach_bbsr/public. Shapefiles of the borders of Germany and of the Federal States are from the Federal Agency of Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie).These shapefiles are available at http://www.geodatenzentrum.de/geodaten/gdz_rahmen.gdz_div?gdz_spr=deu&gdz_akt_zeile=5&gdz_anz_zeile=1&gdz_unt_zeile=15&gdz_user_id=0

We calculate a host of historical variables at the level of planning regions. To account for pre-Roman settlement patterns in the non-Roman areas, we report the number of Celtic settlements (Oppida, i.e., hillforts or princely residences) within a region.[14] For each region, we also create a variable for the number of Roman era settlements and Roman markets or mines. These variables are extracted shapefiles from the DARMC.

We calculate a dummy variable equal to one if a region includes at least one leading member of the medieval German Hanseatic League based on Dollinger (1966).[15] This variable controls for historical openness and social interactions with strangers due to intensive interregional trade relationships and the resulting economic prosperity. Data on the number of historical plague outbreaks in a region are taken from Biraben (1975) who collected information on the spread of the plague in Europe and the Mediterranean from 1347 to 1900. Overall, he recorded 11,180 major outbreaks. Imprecise geographical descriptions and other remaining uncertainties reduce the number of localizable outbreaks to 6,929. We use the geo-located data for these outbreaks provided by Büntgen et al. (2012). Since historical plague outbreaks may have left traces in the regional population we control for this potential influence in our empirical models.[16]

The intersection of a region with the rivers Danube, Elbe, Oder or Rhine indicates relatively easy means of transportation and interregional trade. We account for such an influence with a dummy variable equal to one if a region intersects with one of those rivers.[17] For the same reason we consider a location at

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[14] Information on Celtic settlements come from the Digital Atlas of the Roman Empire (DARE) and the Pleiades Database of Ancient Places that is hosted by the Ancient World Mapping Center (AWMC) of the University of North Carolina. This digital atlas is edited by Johan Ahlfeldt from Lund University. It can be accessed under this url: http://dare.ht.lu.se/. The Pleiades database is from the AWMC website http://awmc.unc.edu/awmc/map_data/shapefiles/cultural_data/Pleiades_data/. We validate and supplement the DARE data based on information in several other historical and archeological publications (Kristiansen 2000; Kuckenburg 2000; Menghin 1995; Rieckhoff and Biel 2001).

[15] Leading members are either the capitals of Hanseatic quarters or cities considered to be important by Dollinger (1966).

[16] The data can be downloaded at https://www.wsl.ch/fileadmin/user_upload/WSL/Landschaft/Landschaftsentwicklung_Monitoring/Landschaftsgeschichte/Historical_plague_outbreaks.txt

[17] Information about the location of these rivers is taken from a shapfile provided by the European Environment Agency (EEA).Downloadable at https://www.eea.europa.eu/data-and-maps/data/wise-large-rivers-and-large-lakes/zipped-shapefile-with-wise-large-rivers-vector-line/zipped-shapefile-with-wise-large-rivers-vector-line/at_download/file

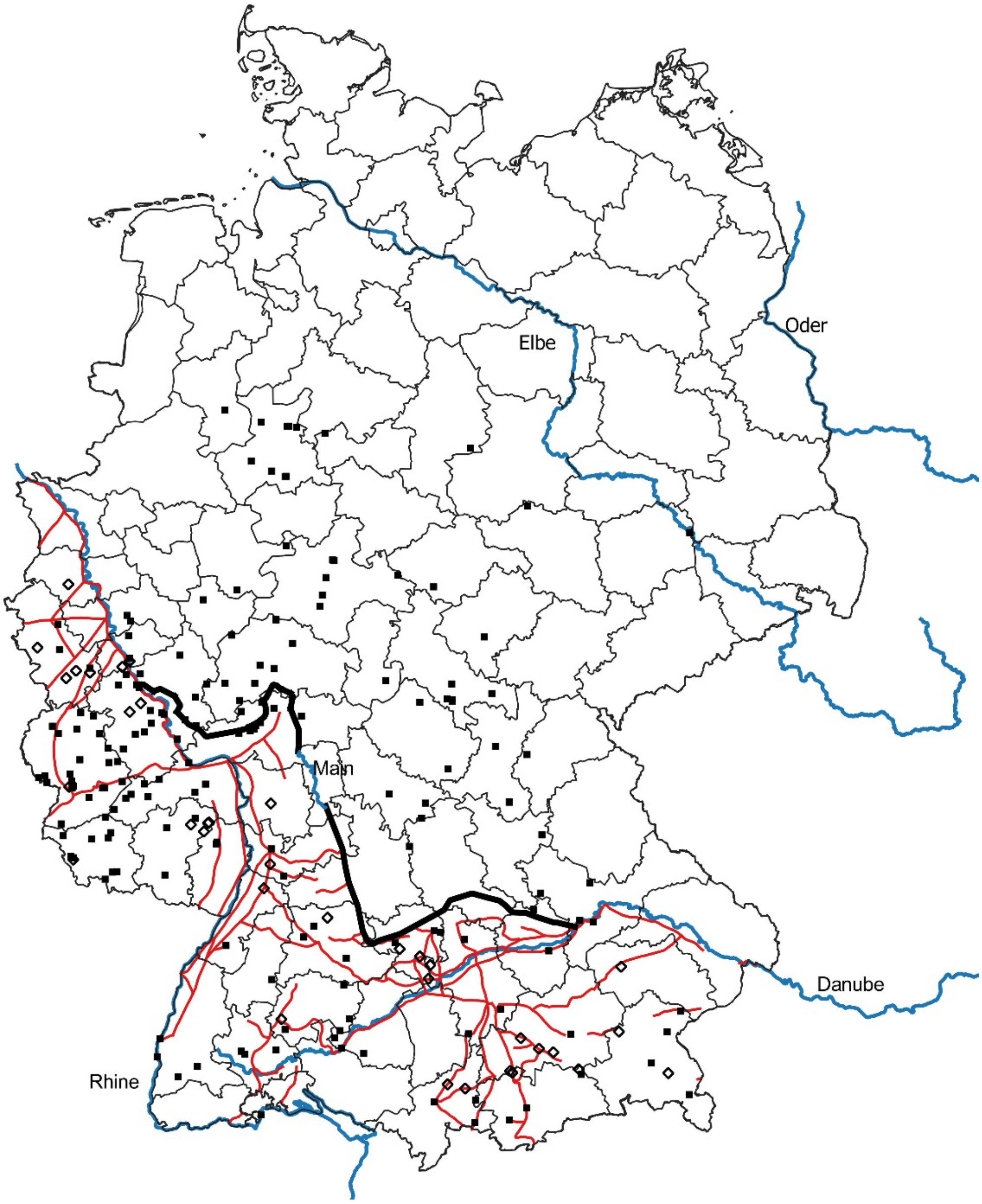
the coast with a respective dummy variable (yes=1, no=0).[18] As further geographic variables we consider the suitability of a region's soils for growing crops (according to Zabel, Putzenlechner and Mauser 2014). This measure reflects a combination of climatic and geographic factors (topography etc.) as well as of soil characteristics (pH value etc.) ranging from 0 (no suitability) to 100 (perfectly suitable). Furthermore, we include measures for the mean elevation in meters and terrain ruggedness (according to a digital elevation model of the EEA) as well as mean sunshine duration and temperatures in July.[19] These variables control for natural conditions in a region.

Finally, we consider the effect that access to coal fields could have on personality traits and socioeconomic outcomes because of its important role in the process of industrialization and the sectoral change of the regional economy (Fernihough and O'Rourke 2014; Stuetzer et al. 2016). As actual coal access and regional coal employment could be endogenous we proxy coal access with the presence of late carboniferous rock strata. Rock strata from the Carboniferous Age are where coal is often found. Hence, coalfield locations should be close or on such rock strata (Fernihough and O'Rourke 2014). We used a geological shapefile of Europe showing the location of those rock strata[20] and created a dummy variable equal to one if there are late carboniferous rock strata in a planning region. Figure 2 shows the historical data alongside the borders of planning regions and the course of large rivers.

[18] A respective shapefile is downloadable at: https://www.eea.europa.eu/data-and-maps/data/eea-coastline-for-analysis-1/gis-data/europe-coastline-shapefile

[19] The digital elevation model is provided as raster file and can be downloaded from https://www.eea.europa.eu/data-and-maps/data/eu-dem. The data from the DWDs Climate Data Center can be accessed at https://opendata.dwd.de/climate_environment/CDC/observations_germany/climate/multi_annual/mean_61-90/. Soil suitability and climate variables are averaged over the period 1961 to 1990.

[20] The shapefile is downloaded from the website of the Federal Institute of Geoscience and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoff). The link to the download is the following: https://download.bgr.de/bgr/Geologie/IGME5000/shp/IGME5000.zip.



Note: The Limes Germanicus (Upper-Germanic and Rhaetian Limes) is the solid black line. Blue solid lines are major rivers (Danube, Elbe, Oder and Rhine). Red solid lines are certain, major Roman roads. Black rectangulars are Celtic Oppida and diamonds indicate the location of a Roman market or mine. The borders are planning region borders.

Figure 2: Planning regions, the Limes Germanicus, Roman roads, markets, mines and Celtic Oppida

4.1.2 Personality traits

Data on the present-day regional personality profile of the local population comes from the German dataset of the global Gosling-Potter Internet Project.[21] The project collected personality data via a non-commercial Internet website. People can voluntarily participate in this study by completing a questionnaire on socio-demographic variables, personality traits, and state of residence. As an incentive, participants received a personality evaluation based on their responses.

In the present analysis, we use the data collected from German respondents between 2003 and 2015 (N = 73,756). The personality profile of the respondents was assessed via the German language version (Rammstedt 1997; Rammstedt and Danner 2007) of the well-established Big Five Inventory (BFI; John and Srivastava 1999), which consists of 44 items (5-point Likert scale, 1 = disagree strongly, 5 = agree strongly). This individual level personality data was then aggregated to the regional level (regional average scores in each Big Five trait) using the zip code of the respondent's current residency.

We combine these five traits into an entrepreneurial profile index resulting in an intraindividual entrepreneurial Big Five profile (entrepreneurial constellation of Big Five traits within the individual). Research at the individual level has often revealed that self-employed people tend to score relatively high on the Big Five personality traits 'extraversion', 'conscientiousness', and 'openness' but score relatively low on 'agreeableness' and 'neuroticism' (Caliendo, Fossen and Kritikos 2014; Zhao and Seibert 2006). Our indicator for an entrepreneurial personality profile measures the deviation from the statistical reference profile of an entrepreneurial personality structure (highest scores on extraversion, conscientiousness, and openness; lowest scores on agreeableness and neuroticism). This fixed reference profile is determined by the outer limits of the single Big Five traits within an entrepreneurial personality structure (see Obschonka and Stuetzer 2017). The individual level entrepreneurial personality fit is the sum of the squared deviations of the individual Big Five scores from this reference profile (the D2 measure of Cronbach and Gleser 1953). The individual

[21] Rentfrow et al. (2008); Bleidorn et al. (2013). For more details on the German dataset see Obschonka et al. (2017).

values on the profile are then aggregated to the regional level (average score based on respondents' current residence) to achieve the regional value. This index has a mean of 19.39 (standard deviation: 0.563) across German planning regions.[22] Empirical research of aggregate values of individual personality scores at the regional level found a robust link between regional variation in this entrepreneurial personality profile and regional variation in regional entrepreneurial activity (Obschonka et al. 2013, 2015; Fritsch, Obschonka and Wyrwich 2019).

4.1.3 Socioeconomic outcomes

A first type of socioeconomic outcome that we are interested in is the effect the Romans had on the current economic vitality of regions. Economic vitality is proxied by the levels of innovative activities and entrepreneurship. Innovation activity is measured as the number of patents per region that is taken from the RegPat database provided by the OECD (see Maraut et al. 2008). Patents as an innovation indicator have a number of advantages and disadvantages (for an overview see Griliches 1990, and Nagaoka, Motohashi and Goto 2010). We consider the average number of patent applications filed in the years 2008 to 2014 with at least one inventor residing in the region per 10,000 workforce. If a patent has more than one inventor, the count is divided by the number of inventors and each inventor is assigned his or her share of that patent. Information on the size of the regional workforce comes from labor market statistics of the German Federal Statistical Office.

Entrepreneurship is measured by the average number of start-up companies per 10,000 economically active population in the years 2008 to 2014. The information on the number of new businesses comes from the Enterprise Panel of the Center for European Economic Research (ZEW-Mannheim). These data are based on information from the largest German credit rating agency (Creditreform).[23]

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[22] See Fritsch, Obschonka and Wyrwich (2019) and Obschonka and Stuetzer (2017) for further details.

[23] As with many other data sources on start-ups, these data may not completely cover the case of all solo entrepreneurs. However, once a firm is registered, hires employees, requests a bank loan, or conducts reasonable economic activities, even solo entrepreneurs are included, and information about their activities is gathered beginning with the 'true' date the firm was established. Hence,

The second type of socioeconomic outcome that we study is psychological well-being and health as indicators of the general well-being of regions. We consider life and health satisfaction as measured by the survey data of the German Socioeconomic Panel (SOEP) on an 11-point Likert scale.[24] These data are averaged over different waves of the survey from 1984 to 2016. Data on life expectancy of a newborn child averaged over the years 2013-2015 comes from the Federal Institute of Research on Building, Urban Affairs and Spatial Development (BBSR).[25] Life expectancy indicates regional health conditions and well-being based on more objective facts as compared to the subjective assessment of life and health satisfaction. Data on the regional Gross Domestic Product per capita is provided by the Federal Statistical Office.

4.1.4 Descriptives

Table A1 in the Appendix provides an overview on the definition of variables and data sources. Table A2 shows some descriptive statistics and Table A3 depicts correlations between the outcome variables including the average regional GDP per capita over the period 1992-2016. There are considerable correlations between this conventional measure of the regional level of economic development and the other outcome indicators, but these correlations are far from perfect. This clearly shows that the set of outcome variables that we focus on in our analysis provides a more comprehensive picture than the GDP measure.

4.2 Empirical Approach

To assess the effect of the Romans on personality traits and socioeconomic outcomes in Germany, we run cross-sectional ordinary least squares (OLS) regressions. We estimate the equation

$$Y_{is} = \alpha + \beta R_{is} + \gamma' \boldsymbol{X}_{\text{is}} + \lambda_s + \varepsilon_{is} \qquad (1)$$

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many solo entrepreneurs are captured along with the correct business founding date. This information is limited to the set-up of a firm's headquarters and does not include the establishment of branches. For details see Bersch et al. (2014).

[24] For the German Socioeconomic Panel see Goebel et al. (2019).

[25] The data can be accessed under https://www.bbsr.bund.de/BBSR/DE/Home/Topthemen/interaktive-karten/lebenserwartung/lebenserwartung.html

where Y_{is} is a socioeconomic outcome. The indices i and s represent regions (i) and federal states (s), respectively. R_{is} is a dummy variable equal to one if region i in federal state s is entirely located in the historically Roman area. $\boldsymbol{X}_{is}$ is a vector of geographical and historical control variables. λ_s are Federal State fixed effects accounting for time invariant unobserved heterogeneity between them. ε_{is} is the error term. We estimate heteroskedasdicity robust standard errors throughout the analysis.

5. Results

5.1 Main results

In an initial step we demonstrate the relationship between Roman legacy and the regional wealth level today by regressing the average Gross Domestic Product (GDP) per capita in the period 1992-2016 on a simple dummy variable that indicates if a planning region was part of the Roman Empire or not. The result indicates a significantly higher GDP per head in those regions once occupied by the Romans.[26] Next, we apply this approach to the Big Five personality traits of the regional population and find statistically significant coefficients of the Roman dummy for all the Big Five as well as for the entrepreneurial personality profile (Table 1). According to these results the population in those regions that were occupied by the Romans nearly 2,000 years ago show higher levels of extraversion, agreeableness, conscientiousness, and openness as well as lower

Table 1: Personality traits and Roman legacy

	(1)	(2)	(3)	(4)	(5)	6)	(7)
Dependent variable	Average GDP per capita 1992-2016	Extraver-sion	Agreeable-ness	Neuroticism	Conscien-tiousness	Openness	Entrepreneurial personality profile
Roman (1=yes)	0.221*** (0.045)	0.0327** (0.0135)	0.0264*** (0.0078)	-0.0467*** (0.0113)	0.0208* (0.0114)	0.0426*** (0.0114)	0.395*** (0.0997)
R^2	0.188	0.042	0.094	0.139	0.025	0.093	0.105

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models.

[26] GDP per capita is also statistically significant when control variables are added to the model. See Table A 4 in the Appendix.

levels of neuroticism. The entrepreneurial personality profile that is a construct based on the Big Five traits, shows also significantly higher scores for the regions of the former Roman Empire. The statistical fit of the models as indicated by the R^2 values is, however, not very high.

Table 2: Personality traits and Roman legacy with control variables

Dependent Variable	(1) Extraversion	(2) Agreeable-ness	(3) Neuroticism	(4) Conscien-tiousness	(5) Openness	(6) Entrepreneurial personality
Roman (1=yes)	0.0433**	0.0156	-0.0568***	0.0517***	0.0090	0.473***
	(0.0192)	(0.0108)	(0.0186)	(0.0186)	(0.0191)	(0.152)
Intersects major river (1=yes)	-0.0136	0.0087	-0.0024	0.0174	-0.0038	-0.0563
	(0.0185)	(0.00921)	(0.0146)	(0.0145)	(0.0161)	(0.145)
Border region (1=yes)	0.0425***	-0.0067	-0.0311**	-0.0182	0.0101	0.298**
	(0.0156)	(0.0087)	(0.0151)	(0.0156)	(0.0155)	(0.129)
Mean elevation	2.10e-05	-3.88e-05	-1.03e-05	-9.86e-05**	9.24e-05*	0.0003
	(5.82e-05)	(3.07e-05)	(4.94e-05)	(4.77e-05)	(5.34e-05)	(0.0005)
Terrain ruggedness	0.0001	0.0001*	-0.0001	-2.88e-05	0.000156	0.0009
	(0.0001)	(7.00e-05)	(0.0001)	(9.44e-05)	(0.0001)	(0.0009)
Soil suitability	-0.0008	0.0007*	0.0006	0.0008	0.0001	-0.0040
	(0.0007)	(0.0004)	(0.0007)	(0.0007)	(0.001)	(0.0063)
Coastal region (1=yes)	-0.0454	-0.0345**	-0.0213	-0.0562*	0.0536**	0.0575
	(0.0361)	(0.0167)	(0.0277)	(0.0308)	(0.0240)	(0.307)
Number of Celtic Oppida	-0.0036**	-0.0017***	0.0022*	-0.0061***	0.0019	-0.0260**
	(0.0017)	(0.0006)	(0.0013)	(0.0012)	(0.0018)	(0.0118)
Mean sunshine duration	-0.0005**	0.0002	6.29e-05	-0.000113	-4.86e-05	-0.0032*
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0018)
Mean temperature	0.0013	0.00091	0.0039	-0.0119	0.0251***	0.0593
	(0.0106)	(0.0059)	(0.0089)	(0.0085)	(0.0092)	(0.0721)
Hanseatic League	0.0065	0.01	-0.0116	0.0096	0.006	0.108
	(0.0203)	(0.0107)	(0.0171)	(0.0207)	(0.0169)	(0.168)
Number of plague outbreaks	0.0016***	0.0001	-0.0009*	-0.0011*	0.0022***	0.0108**
	(0.0006)	(0.0003)	(0.0005)	(0.0006)	(0.0006)	(0.004)
Carboniferous rock strata	0.0103	-0.0297***	0.0168	-0.0490**	0.0130	-0.0871
	(0.0168)	(0.00975)	(0.0157)	(0.0208)	(0.0196)	(0.133)
R^2	0.328	0.291	0.263	0.247	0.321	0.271

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models.

Including control variables that may have an effect on the personality traits of the populations leads to statistical insignificance of agreeableness and openness while the entrepreneurial personality fit remains highly statistically significant (Table 2). It is remarkable that only some of the control variables are statistically significant. There are significant relationships between some of the personality traits and being located at the border or at the coast, the mean temperature, sunshine duration, and the number of plague outbreaks in the Middle Ages. Variables that indicate characteristics of the landscape and quality of the soil (mean elevation, terrain ruggedness, soil suitability) are never statistically significant. The number of Celtic Oppida is statistically significant in four of the six models. Quite interestingly, those coefficients of this variable that are statistically significant assume an opposite sign as the dummy for being part of the Roman Empire. This underlines the differences of the personality traits between Roman regions and those of the German barbarians.

Table 3: Personality traits and Roman legacy—including Federal State fixed effects

Dependent Variable	(1) Extraver-sion	(2) Agreeable-ness	(3) Neuroticism	(4) Conscientious-ness	(5) Openness	(6) Entrepreneurial personality
Roman (1=yes)	0.0316*	0.0187*	-0.0467**	0.0528**	0.0081	0.368**
	(0.0189)	(0.0110)	(0.0213)	(0.0201)	(0.0196)	(0.167)
Intersects major river (1=yes)	-0.0117	0.0080	-0.0013	0.0200	-0.0083	-0.0706
	(0.0196)	(0.0107)	(0.0156)	(0.0164)	(0.0181)	(0.163)
Border region (1=yes)	0.0390**	-0.0028	-0.0380**	-0.0087	0.0110	0.343**
	(0.0165)	(0.0097)	(0.0147)	(0.0163)	(0.0151)	(0.136)
Mean elevation	8.07e-05	-5.39e-05	2.01e-05	-0.0001	0.0002*	0.0007
	(8.51e-05)	(4.55e-05)	(8.97e-05)	(7.31e-05)	(8.21e-05)	(0.0007)
Terrain ruggedness	0.0001	0.0001**	-0.0002	-2.71e-05	0.0001	0.0009
	(0.0001)	(6.95e-05)	(0.0001)	(0.0001)	(0.0001)	(0.0009)
Soil suitability	-0.0007	0.0008	0.0008	0.0012	0.0002	-0.0051
	(0.0009)	(0.0005)	(0.0008	(0.0009)	(0.0012)	(0.0086)
Coastal region (1=yes)	-0.0456	-0.0349*	-0.0103	-0.0623*	0.0718**	0.0523
	(0.0391)	(0.0197)	(0.0301)	(0.0348)	(0.0278)	(0.335)
Number of Celtic Oppida	-0.0047**	-0.0013	0.0015	-0.0069***	0.0011	-0.0316**
	(0.0021)	(0.0009)	(0.0017)	(0.0015)	(0.0023)	(0.0151)
Mean sunshine duration	-0.0003	9.34e-05	0.0001	-0.0003	1.17e-05	-0.0025
	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0018)
Mean temperature	0.0057	-0.0025	0.0083	-0.0235**	0.0290**	0.0698
	(0.0115)	(0.0071)	(0.0114)	(0.0108)	(0.0114)	(0.0960)
Hanseatic League	-0.0047	0.0084	-0.0002	0.004	0.0124	0.0537
	(0.0209)	(0.0129)	(0.0176)	(0.0226)	(0.0188)	(0.184)
Number of plague outbreaks	0.002***	0.0002	-0.0011*	-0.0007	0.0023***	0.0127**
	(0.0006)	(0.0004)	(0.0005)	(0.0007)	(0.0007)	(0.0049)
Carboniferous rock strata	0.0148	-0.0236*	0.006	-0.0684**	0.0128	-0.0721
	(0.0259)	(0.0119)	(0.0208)	(0.0303)	(0.0364)	(0.171)
Federal State dummies	Yes*	Yes	Yes***	Yes	Yes	Yes
R^2	0.428	0.313	0.334	0.287	0.358	0.316

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models.. Significance stars after the “Yes” indicate the level of joint significance of the Federal State dummies.

Table 4: Socioeconomic outcomes and Roman legacy

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable	Life Satisfaction		Health Satisfaction		Life Expectancy		ln(Patents)		Start-Up Rate	
Roman (1=yes)	0.164***	0.313***	0.177***	0.209**	0.987***	0.562**	0.885***	0.570***	3.301**	9.030***
	(0.0512)	(0.0868)	(0.0455)	(0.0845)	(0.167)	(0.225)	(0.121)	(0.177)	(1.408)	(1.800)
Intersects major river		-0.106		-0.0224		-0.0476		-0.266*		-0.972
(1=yes)		(0.0670)		(0.0591)		(0.164)		(0.149)		(1.522)
Border region (1=yes)		0.122**		0.106		0.0701		0.462***		2.594*
		(0.0592)		(0.0696)		(0.173)		(0.151)		(1.409)
Mean elevation		6.53e-05		6.81e-05		0.000864		0.0013***		0.0027
		(0.0003)		(0.0002)		(0.0006)		(0.0005)		(0.0051)
Terrain ruggedness		-0.0005		-5.64e-05		0.002		0.001		-0.0026
		(0.0006)		(0.0005)		(0.0014)		(0.001)		(0.0121)
Soil suitability		-0.00234		0.000659		0.0120		0.00338		-0.273***
		(0.0032)		(0.0027)		(0.0083)		(0.0058)		(0.0797)
Coastal region (1=yes)		0.108		0.0891		-0.0479		-0.0354		4.481*
		(0.128)		(0.0980)		(0.295)		(0.259)		(2.427)
Number of Celtic Oppida		0.0002		-0.0052		-0.0225		-0.0357**		-0.272
		(0.0053)		(0.0051)		(0.0139)		(0.0152)		(0.184)
Mean sunshine duration		-0.0016		-0.0006		-0.001		-0.002		-0.0399***
		(0.001)		(0.0007)		(0.0015)		(0.0014)		(0.0124)
Mean temperature		-0.0672		-0.0700*		0.200*		0.122		-0.0641
		(0.0536)		(0.0415)		(0.101)		(0.0864)		(0.807)
Hanseatic League		0.0710		0.0446		0.0507		-0.0371		-1.783
		(0.111)		(0.0915)		(0.250)		(0.188)		(2.205)
Number of plague		0.0005		-5.84e-05		0.0034		0.0087		0.225***
outbreaks		(0.0032)		(0.0028)		(0.0064)		(0.0057)		(0.0636)
Carboniferous rock strata		-0.0205		0.0438		-0.821***		-0.263		-0.941
		(0.0995)		(0.0907)		(0.243)		(0.190)		(1.508)
R^2	0.064	0.202	0.102	0.205	0.291	0.510	0.293	0.576	0.054	0.346

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations regions is 96 in all models.

Including dummy variables for the current German Federal States in order to control for influences of current policies (Table 3) does not lead to any major changes of the results. In particular, the results for the Roman dummy remain rather robust. This is not surprising as the Federal State dummies are only jointly significant for neuroticism and extraversion. Thus, there seems to be not much of a systematic variation between current Federal States in those traits.

Turning to socioeconomic outcomes, we find positive relationships between Roman occupation and life and health satisfaction as well as life expectancy of the regional population (Table 4). There are also pronounced and statistically significant positive relationships between the Roman dummy, the number of patents per workforce and the number of business start-ups per workforce. All results for the Roman dummy remain statistically significant with a positive sign if the set of control variables is included.

However, the statistical significance of the Roman dummy decreases considerably if Federal State dummies are included as reported in Table A5 in the Appendix. This might indicate that the socioeconomic outcomes are more affected by current policies than the Big Five personality traits that should be relatively stable over time. The significantly negative relationship between carboniferous rock strata and conscientiousness is in line with other studies that examined the effect of coal-based industries (near coalfields) on regional personality traits in the UK and the US (Obschonka et al. 2018).

5.2 Where does the effect of the Romans come from?

We focus on two particularly promising mechanisms for a long lasting effect of the Romans on current regional performance, Roman roads and the number of Roman markets and mines. Either mechanism could have led to the development and persistence of a local ‘entrepreneurial culture’ due to selective migration on the one hand and persistence of economic activity since Roman times on the other. We run the models with all the control variables but with the density of Roman roads and the number of Roman markets and mines as indicators for the Roman presence instead of a simple dummy variable (Table 5). There is a certain overlap between both measures[27] and many cities located at Roman roads that were not original centers of the Roman economy in Germania, developed into trade centers in later periods. In this sense, one may suppose that the effect of markets and mines is likely to pick-up an ‘early start advantage’ of the original Roman economic centers.

According to the results, density of road infrastructure built by the Romans shows a statistically significant effect on life satisfaction, life expectancy, the number of patents per population and the start-up rate (Panel A in Table 5). While there is a negative relationship with neuroticism the relationship with conscientiousness is not statistically significant. While the relationship with the other three personality traits is also insignificant[28] the entrepreneurial personality profile that is a combination of all five traits (see Section 4.1.2) is significant with the expected positive sign.

Table 5: Personality traits, socioeconomic outcomes and Roman legacy

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Neuroticism	Conscientiousness	Entrepreneurial personality	Life satisfaction	Life expectancy	ln(Patents)	Start-up rate
			Panel A: Roman road density				
Roman road density	-0.925***	0.126	6.498**	6.240***	12.04***	11.74***	119.5**
	(0.313)	(0.289)	(2.824)	(1.833)	(4.083)	(3.099)	(47.00)
R^2	0.238	0.188	0.240	0.205	0.518	0.679	0.299
			Panel B: Number of Roman markets & mines				
Number of Roman markets & mines	-0.0197***	0.0135**	0.151***	0.0549**	0.137	0.0744	2.004*
	(0.00523)	(0.00606)	(0.0533)	(0.0261)	(0.0830)	(0.0522)	(1.119)
R^2	0.249	0.215	0.253	0.129	0.488	0.643	0.278
			Panel C: Roman road density and number of markets & mines				
Roman road density	-0.583*	-0.249	3.700	6.297***	11.19**	12.72***	91.61**
	(0.311)	(0.313)	(3.215)	(2.089)	(4.288)	(3.381)	(40.97)
Number of Roman markets & mines	-0.0143**	0.0158**	0.118*	-0.00239	0.0356	-0.0413	1.170
	(0.00559)	(0.00632)	(0.0674)	(0.0305)	(0.0841)	(0.0524)	(1.125)
R^2	0.266	0.218	0.261	0.206	0.519	0.680	0.315
Observations	96	96	96	96	96	93	96
Controls Included	Yes*	Yes**	Yes*	Yes	Yes***	Yes***	Yes***

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models. Controls are identical to the ones included in Tables 2 and 4. Significance stars after the “Yes” indicate the lowest level of joint significance of the control variables.

[27] The correlation coefficient between the two measures is 0.501.

[28] The models are omitted here to economize on space.

Running the models with the number of markets and mines as indicator for Roman presence shows slightly stronger relationships for the personality traits but weaker relationships for the socioeconomic outcomes; the relationships with life expectancy and patents is insignificant while the relationship with the start-up rate is only statistically significant at the 10% level. Including both variables, Roman road density and the number of Roman markets and mines into the models (Panel C in Table 5) clearly indicates that markets and mines are more strongly related to the personality traits while Roman road density is more closely related to the socioeconomic outcomes. These patterns of results are robust when Federal State dummies are included (see Table A5 in the Appendix).

The evidence supports the notion that Roman roads are an important mechanism for a persistent effect of Roman presence on regional performance over long periods of time as described in Section 2.1. The relationship is considerably stronger with current socioeconomic outcomes than for explaining personality traits.

5.3 Further results for historical outcomes

Until now we have only investigated the relationship between variables determined at Roman times and variables determined today. However, if there is really a persistent effect of the Romans, it should also be visible when looking at earlier outcomes from the long time period between Roman presence and today. To test whether we find a Roman effect in these periods we use data sets from other studies that related to 15th and 16th century.

One of these data sets is the study of Dittmar and Meisenzahl (2019) containing information for 239 German-speaking cities for which Bairoch, Batou and Chevre (1988) offer city population figures in 1800. This data set is a cross section where most of the variables are measured in the 15th or 16th century. Based on the information about the course of the Roman border we assign each city to the Roman and the Germanic part. We also create a dummy variable if a city is located closer than 5km from a Roman road. Among the variables in this data set the average number of students in a city between 1458 and 1508 and the number of books printed before 1517 are of most interest to us, as they could proxy for innovativeness and human capital back then. Apart from these two variables we include a host of control variables coming from their data set, like dummy variables for cities that were members of the Hanseatic League, had a university or are located on a river, among others. As both outcome variables are count data, we estimate Poisson models here. We also include territory fixed effects and report heteroskedasticity robust standard errors.

Table 6: Roman Legacy and Medieval Economic Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Number of students 1458-1508		Number of books pre 1517		Number of markets in 1470		Share of economic buildings 1400-1600	
Data set	Dittmar and Meisenzahl (2019)				Cantoni et al. (2018)			
Method	Poisson				OLS			
Roman (1=yes)	0.628*** (0.193)		2.937*** (0.812)		0.111 (0.069)		0.0198** (0.0088)	
Roman road (1=yes)		0.228 (0.179)		0.916* (0.497)		0.137* (0.0751)		0.0194* (0.0106)
(Pseudo) R^2	0.471	0.464	0.504	0.488	0.086	0.087	0.037	0.036
Number of observations	229	229	229	229	2218	2218	2218	2218
Controls Included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. In columns (1)-(4), following control variables are always included: a river, Hanseatic League, university by 1517 and Reformation law before 1600 dummy, the number of monasteries of non-mendicant orders and the Augustinians within 10km of the city in 1517, the natural logarithm of a city's distance to Wittenberg and territory dummies are included. For the sources see Dittmar and Meisenzahl (2019). In columns (5)-(8), the controls are a university by 1517 (from Dittmar and Meisenzahl), city near the border of a different religious denomination dummy, a Protestant dummy and a variable indicating which noble family ruled the territory in 1500. For the sources see Cantoni et al. (2018)

Columns (1) to (4) in Table 6 show the results of the Poisson regressions. These estimates suggest that cities in the historically Roman part of Germany had significantly more students (even when controlling for university location) and more printed books in the 15th and 16th century. This implies that their human capital stock and probably also their level of innovativeness were already higher during the late Middle Ages. Location close to a Roman road does however, only matter for explaining the number of students, not the number of books. This suggests that Roman roads are only one of several mechanisms explaining the effect of the Romans on these outcomes.

Next, we use the data set of Cantoni, Dittmar and Yuchtman (2018) that provides information on historical construction activities in all 2,257 cities in the German Empire (as of 1937) that ever had city rights. This data set provides yearly information for the period from 1400 to 1600. Information on construction activities in those cities comes from the "*Deutsche Städtebuch*" (Handbook of German Cities) edited by Keyser and Stoob (1939–1974). From the information in the *Städtebuch*, Cantoni et al. (2018) also take information on the number of markets in each of the cities in 1470. Their data set also includes other variables such as a dummy for Protestant religion, and on the number of Monasteries in the region around a city (and whether they were closed in course of the Reformation or not).

We are interested in testing whether cities in the Roman area had more markets and constructed more economic buildings. We calculate the average number of buildings constructed in each year between 1400 and 1600 and then calculate the share of economic buildings. As before, we assign each city in their data set to the historically Roman part of Germany or to the non-Roman part based on our map of the Limes and we assess whether a city was located within 5km from a Roman road. We include several controls from the data sets of Cantoni et al. (2018) and that of Dittmar and Meisenzahl (2019), among them a dummy for the presence of a university in 1517, and a dummy for cities that became Protestant.

Columns (5) to (8) of Table 6 report the results of OLS estimations explaining the number of markets and the share of economic buildings with a Roman dummy or a Roman road dummy and controls. It turns out that both cities in the Roman area as well as those located close to Roman roads had significantly more markets and significantly higher shares of economic buildings. This suggests that those cities were centers of trade and commerce already during the late Middle Ages and the early modern period.

Finally, we re-estimate the regressions from Table 4, column (8) and Table 5, column (4) using the average number of patents per capita in 1890, 1900 and 1910 as an outcome variable. We obtained these data from the historical patent database of Donges, Meier and Silva (2019) which is an extended and updated version of the patent database by Streb, Baten and Shuxi (2006). Their data is on the level of counties in 1900 and we aggregate them up to contemporary planning regions by assigning each historical county to the planning region where it is located and then we calculate the sum of all historical patents in a contemporary planning region. We also calculate the historical population of a planning region and then divide the number of historical patents by the historical population to arrive at the number of historical patents per capita. Table 7 shows the results of the regressions using this historical patent activity measure. We find a significant and positive Roman dummy also for historical patent activity.

Table 7: Historical Patent Activity and Roman Legacy

	(1)	(2)
Dependent variable	ln(historical patents)	
Roman (1=yes)	0.906**	1.013**
	(0.376)	(0.425)
Federal State dummies	No	Yes
Controls included	Yes**	Yes*
R^2	0.233	0.296

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models. Controls are identical to the ones included in Tables 2 and 4. Significance stars after the "Yes" indicate the lowest level of joint significance of the control variables and Federal State Dummies.

All in all, the results are not only in line with previous results on the persistent development effect of Roman legacies in Germany (Wahl 2017) but also show that the Roman part of Germany was more economically vibrant and had a better human capital stock and more patenting activity already in earlier periods. However, we are not able to test the persistence of personality traits as there exists no historical psychological survey data that would allow us to do so. The same applies to entrepreneurship since there is no information on historical start-up activity. However, there could well be an underlying cultural pathway, imprinted by Roman rule, and with various corresponding expressions in local outcomes over the centuries, including human capital and economic activity between the 15th and 20th century and also present-day personality characteristics as indicated by our results.

5.4 Robustness checks

To challenge the robustness of our findings, we conduct several robustness checks reported in Tables A5 and A6 in the Appendix. First, it is important to ensure that the results hold when one considers other, more recent historical borders that might have had important cultural effects. Among those other relevant historical borders, the border of the German areas briefly occupied by the French during the Napoleonic period, the border of the former socialist GDR (German Democratic Republic) and those of the allied occupation zones after World War II are most prominent. However, the borders of the occupation zones were identical to borders of current Federal States in all but one case, that is the border of the French occupation zone through contemporary Baden-Württemberg. Thus, by including Federal State fixed effects, we already account for all the occupation zones but the French one. The same is true for the border of the GDR, that is completely identical to the border of the contemporary eastern Federal States (Brandenburg, Mecklenburg-West Pomerania, Saxony-Anhalt, Saxony and Thuringia).[29] Again, the Federal State fixed effects completely account for a possible "GDR effect"—the potential long term cultural influence of four decades of socialism. Our results indicate that above and beyond a potential imprint of socialism and the massive social change during the rapid transition to capitalism in East Germany since 1990, the Limes and the deep, lasting imprint of the Romans seems to be an even deeper underlying "line of fate" separating German regions today, culturally, economically, and in terms of the population well-being.

Finally, it can be useful to have a look at alternative innovation and entrepreneurial activity measures. We consider the number of high tech start-ups per 10,000 inhabitants as a more specific measure combining information about the local level of entrepreneurial spirit of innovativeness. Furthermore, we look at regional share of employees working in the R&D sector. For both measures, we look at the average numbers during the period from 2008 to 2014. Results for these dependent variables are shown in Table A7. As before, we first run

[29] The contemporary city and Federal State of Berlin does include both the Western and Eastern parts of Berlin. However, the western part of Berlin was split itself into four occupation zones. We cannot use this variation as we only have data on the contemporary planning region consisting of the reunified Berlin.

regressions including a full set of controls and then we additionally include Federal State fixed effects. For both variables the results suggest a significant and positive relationship to the Roman dummy. There are on average more high tech start-ups per workforce in the Roman part of Germany and the share of R&D employees is also higher. In sum, none of our baseline results is invalidated by the conducted robustness checks.

6. Conclusions

We presented empirical evidence for a statistically significant relationship between being part of the Roman Empire nearly 2,000 years ago, personality traits of today’s population, and several current socioeconomic outcomes. These statistical relationships remained rather robust when controlling for a number of alternative explanations such as locational characteristics, climate, quality of the soil, the number of plague outbreaks in the Middle Ages or being a main center of Roman trade. According to our results, the population in the former Roman areas has higher levels of conscientiousness, extraversion lower levels of neuroticism, a higher prevalence of an entrepreneurial personality profile, higher levels of life and health satisfaction, longer life expectancy, is more inventive, and tends to found new companies more often (in line with the personality profiles).

Although we have no definite explanation of the transmission of the Roman ‘effect’ over the period of nearly 2,000 years, there is solid indication that the density of the Roman road network played an important role. This had an influence on the level of interregional mobility and the geography of social and economic interactions. In particular, higher levels of mobility and interregional interactions could very likely affect the attitudes of the population towards strangers, its level of risk aversion and tolerance towards change as well as its openness to new ideas. It is also important to note that these routes connected this part of Germany with the Roman Empire. Hence, this road network could have helped to establish a certain early civilization advantage in these German regions, compared to the less developed “barbaric” cultures North of the Limes.

Another reason for expecting a relationship between Roman legacy, current personality traits and socioeconomic outcomes builds on the presence of Roman markets and mines that indicate high levels of economic and social activity. High activity levels may have created pronounced incentives for creativity and innovativeness and may, therefore, have attracted people with such traits to these places. In our statistical analysis the number of Roman markets and mines turned out to be statistically significant for some of our outcome indicators, but the relationship was much weaker than for the density of Roman roads.

Whether, among others, selective migration of like-minded people into the Roman area or the persistence of specific characteristics of the Roman population of the area (maybe an already existing entrepreneurial spirit or higher openness or less risk aversion) are responsible can therefore not be investigated empirically. The Roman part of Germany was inhabited by Roman soldiers and their relatives from all over the Empire. Therefore, the population was comparatively heterogeneous. This also suggests that the population of Roman Germany could have been characterized by a higher level of creativity, openness and tolerance.[30] However, this is speculation and the vast migration movements following the demise of the Roman Empire make it very difficult to assess this aspect. Nevertheless, Gomtsyan (2017) provides evidence in this direction, by showing that cities in the former Roman part of Germany experienced higher in-migration rates than others, that this is still true today and that these migration movements have shaped the attitudes of the city's residents towards migration.

Our results also add to the ongoing debate in Germany about today's (growing) North-South divide that seems to be so influential for regional disparities in a range of socioeconomic outcomes and their persistence (e.g., Lammers 2003). Our data illustrate how 'deep' this divide goes, even with respect to corresponding personality traits and personal well-being, in addition to economic outcomes. Hence, public policies addressing the economic divide should also consider the deep cultural and psychological divide, and the common historical roots behind these regional patterns (Abdellaoui et al. 2019; Obschonka et al. 2018; Talhelm et al. 2014).

Our findings contribute to the literature linking history and its long lasting effects to present-day outcomes with a particular consideration of "soft factors"

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[30] Ashraf and Galor (2013) theoretically and empirically show that in-group genetic diversity is positively related to creativity and innovativeness, as for example, measured by scientific output.

such as culture (e.g., Alesina and Giuliano, 2015; Diamond and Robinson 2010; Guiso, Sapienza and Zingales 2006; Nunn 2009, 2012). What is particularly interesting and impressive is that this “Roman effect” seems to be able to ‘survive’ the many disruptive changes that the German regions experienced over the centuries such as in- and out-migration of population, devastating wars and diseases, changing administrative borders and political regimes, changing religions as well as—last but not least—enormous developments of technology, social practices, and a pronounced increase of economic welfare. This would imply that our understanding of such disruptive changes, including today’s policy schemes that address the essential socioeconomic well-being of local populations such as innovation, entrepreneurship, and population well-being, needs to be informed by an updated understanding of underlying historical path dependencies that run deep in the regions and local populations.

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Appendix

Table A1: Definition of variables

Variable	*Definition*	*Data source*
Roman	Dummy variable for a planning region being completely Roman territory in the 2nd century AD (=1) or not (=0)	McCormick et al. (2013)
Density of Roman roads	Kilometers of major Roman road per km²	McCormick et al. (2013)
Numbers of Roman markets and mines	Number of Roman Markets and Mines in a region	McCormick et al. (2013)
Extraversion	Measure of the Big Five personality trait extraversion (being outgoing, energetic) on a five-point Likert scale. Average value of a sample of the regional population.	Gosling–Potter Internet project (http://www.outofservice.com). For details see Rentfrow et al. (2008).
Agreeableness	Measure of the Big Five personality trait agreeableness (being friendly, compassionate) on a five-point Likert scale. Average value of a sample of the regional population.	See above.
Neuroticism	Measure of the Big Five personality trait neuroticism (being nervous, not very resilient) on a five-point Likert scale. Average value of a sample of the regional population.	See above.
Conscientiousness	Measure of the Big Five personality trait conscientiousness (being efficient and organized) on a five-point Likert scale. Average value of a sample of the regional population.	See above.
Openness	Measure of the Big Five personality trait openness to experience (being inventive, curious) on a five-point Likert scale. Average value of a sample of the regional population.	See above.
Entrepreneurial personality profile	Sum of the squared deviations of the individual Big Five scores from the reference profile of an ideal entrepreneurial personality (highest scores on extraversion, conscientiousness, and openness; lowest scores on agreeableness, and neuroticism).	See above.
Life satisfaction	Response to the question “How satisfied are you with your life, all things considered? measured on an eleven-point Likert scale. Averaged for the period 1984-2016.	German Socio-economic Panel (SOEP)
Health satisfaction	Response to the question “How satisfied are you with your health?” measured on an eleven-point Likert scale. Average for the period from 1984-2016.	SOEP
Life expectancy	Life expectancy of a newborn child, averaged over the years 2013-2015	Offical statistics from the Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR)
Patents per workforce	Average Number of patent applications in 2008 to 2014 by 10,000 employees	RegPat database of the OECD (version February 2019)
Historical Patents per capita	Average number of Patents per capita in 1890,1900 and 1910 in the region	Donges et al. (2019)/ Streb et al. (2006)
Start-up rate	Average number of new businesses in a region in the years 2008 to 2014 over 10 thousand persons in the workforce.	Enterprise Panel of the Center for European Economic Research (ZEW-Mannheim)
High tech Start-up rate	Average number of new high tech businesses in a region in the years 2008 to 2014 over 10 thousand persons in the workforce.	Enterprise Panel of the Center for European Economic Research (ZEW-Mannheim)

R&D employment share	Average share of employees working in the R&D sector in 2008 to 2014	German Establishment History Panel
Gross Domestic Product (GDP) per population	Average Gross Domestic Product in German planning regions for the period	Federal Statistical Office
Intersection major river	Dummy variable for a planning region intersecting with a major river (Danube, Elbe, Oder or Rhine) (=1) or not (=0)	WISE Large Rivers and Lakes dataset provided of the European Environment Agency (EEA)
Border region	Dummy variable for a planning region intersecting with the Roman border in 200 AD (=1) or not (=0)	Own calculation using QGIS
Coastal region	Dummy variable for a planning region being located on the coast line (=1) or not (=0)	Europe coastline shapefile from the EEA
Mean elevation	Mean elevation of a planning region in m.	Digital Elevation Model over Europe (Euro-DEM) of the EEA. The resolution of the raster data is 1 arc second.
Terrain ruggedness	Standard deviation of a planning region's elevation	Own calculation using QGIS
Soil suitability	Average suitability of a planning region's soils to grow the 16 globally most important food and energy crops (from 1961 to 1990)	Zabel et al. (2014)
Mean sunshine duration	Mean hours of sunshine in July (from 1961 to 1990).	Deutscher Wetterdienst (DWD)
Mean temperature	Mean temperature in July (from 1961 to 1990).	Deutscher Wetterdienst (DWD)
Number of Celtic Oppida	Number of Celtic Oppida in a region.	Atlas of the Roman Empire (DARE); Pleiades Database of Ancient Places; Kristiansen (2000); Kuckenburg (2000); Menghin (1995); Rieckhoff and Biel (2001)
Hanseatic League	Dummy variable for a planning region being an important member of the Hanseatic League (either a capital of a quarter or otherwise considered to be a leading city)	Dollinger (1966)
Number of plague outbreaks	Number of major historical plague outbreaks in a planning region	Biraben (1975); Büntgen et al. (2012)
oniferous rock strata	Dummy variable for a planning region having late carboniferous rock strata (=1) or not (0)	Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
Federal State dummies	Dummy variable assigning each planning region to a Federal State.	Bundesamt für Kartographie und Geodäsie (shapefile of Federal State borders)

Table A2: Descriptive statistics

Variable	Mean	Minimum	Maximum	Standard deviation
Agreeableness	3.460	3.323	3.594	0.040
Border region	0.188	0.000	1.000	0.392
Carboniferous rock strata	0.125	0.000	1.000	0.332
Coastal region	0.115	0.000	1.000	0.320
Conscientiousness	3.539	3.358	3.677	0.062
East Germany	0.219	0.000	1.000	0.416
Entrepreneurial personality profile	-19.377	-21.215	-18.220	0.566
Extraversion	3.390	3.116	3.547	0.074
French OZ	0.125	0.000	1.000	0.332
GDP per capita (average 1992-2016)	10,145	9,685.6	10,817.5	0.238
Hanseatic League	0.156	0.000	1.000	0.365
Health satisfaction	6.697	5.972	7.352	0.258
High-tech Start-up rate	2.285	0.907	5.499	0.741
Intersects major river	0.385	0.000	1.000	0.489
Life expectancy	80.690	78.779	82.794	0.853
Life satisfaction	7.064	6.110	7.680	0.303
ln Patents per workforce	1.353	-0.998	2.707-	0.762
ln Historical Patents per capita	1.795	1.276	0	4.218
Mean elevation	264.425	1.360	922.738	217.409
Mean sunshine duration	204.137	0.000	247.400	34.766
Mean temperature	16.963	14.467	18.857	0.891
Napoleon	0.177	0.000	1.000	0.384
Neuroticism	3.020	2.856	3.161	0.058
Number of Celtic Oppida	1.844	0.000	22.000	3.543
Number of plague outbreaks	7.646	0.000	46.000	10.577
Number of Roman markets and mines	0.365	0.000	4.000	0.884
Openness	3.721	3.532	3.872	0.065
Roman	0.313	0.000	1.000	0.466
Roman road density	0.012	0.000	0.097	0.021
Share R&D employees	1.981	0.752	4.51	0.783
Soil suitability	41.713	4.592	71.144	12.402
Start-up rate	34.547	23.374	59.151	6.636
Terrain ruggedness	88.861	4.232	317.405	70.417

Table A3: Correlations among outcome variables

		1	2	3	4	5	6	7	8	9	10	11	12
1	Ln (GDP per capita)	1.00											
2	Roman (1=yes)	0.43 (0.00)	1.00										
3	Extraversion	0.44 (0.00)	0.21 (0.04)	1.00									
4	Agreeable-ness	0.22 (0.03)	0.31 (0.00)	0.30 (0.00)	1.00								
5	Neuroticism	-0.34 (0.00)	-0.37 (0.00)	-0.52 (0.00)	-0.39 (0.00)	1.00							
6	Conscien-tiousness	-0.07 (0.50)	0.16 (0.13)	0.20 (0.05)	0.32 (0.00)	-0.42 (0.00)	1.00						
7	Openness	0.55 (0.00)	0.30 (0.00)	0.42 (0.00)	0.24 (0.02)	-0.19 (0.06)	-0.29 (0.00)	1.00					
8	Entrepre-neurial spirit	0.46 (0.00)	0.32 (0.00)	0.82 (0.00)	0.22 (0.03)	-0.78 (0.00)	0.42 (0.00)	0.47 (0.00)	1.00				
9	Life expectancy	0.63 (0.00)	0.54 (0.00)	0.46 (0.00)	0.43 (0.00)	-0.52 (0.00)	0.12 (0.23)	0.48 (0.00)	0.54 (0.00)	1.00			
10	Life satisfaction	0.60 (0.00)	0.25 (0.01)	0.28 (0.01)	0.09 (0.37)	-0.22 (0.03)	-0.13 (0.20)	0.28 (0.01)	0.25 (0.01)	0.36 (0.00)	1.00		
11	Health satisfaction	0.58 (0.00)	0.32 (0.00)	0.19 (0.06)	0.15 (0.16)	-0.23 (0.02)	-0.07 (0.50)	0.30 (0.00)	0.23 (0.02)	0.42 (0.00)	0.83 (0.00)	1.00	
12	In (Patents)	0.70 (0.00)	0.54 (0.00)	0.51 (0.00)	0.28 (0.01)	-0.40 (0.00)	0.00 (0.98)	0.46 (0.00)	0.51 (0.00)	0.77 (0.00)	0.50 (0.00)	0.49 (0.00)	1.00
13	Start-up rate	0.74 (0.00)	0.37 (0.00)	0.49 (0.00)	0.25 (0.01)	-0.46 (0.00)	0.03 (0.80)	0.57 (0.00)	0.55 (0.00)	0.61 (0.00)	0.38 (0.00)	0.37 (0.00)	0.58 (0.00)

Table A4: Regional Gross Domestic Product per capita and Roman legacy

Dependent Variable	ln(GDP per capita)					
	(1)	(2)	(3)	(4)	(5)	(6)
Roman (1=yes)	0.221***	0.243***	0.1902**			
	(0.045)	(0.0630)	(0.0721)			
Roman road density				4.569***		4.785***
				(1.604)		(1.559)
Number of Roman					0.0345	-0.00909
markets & mines					(0.0341)	(0.0338)
Intersect major river		-0.0500	-0.0476	-0.0515	0.00587	-0.0561
(1=yes)		(0.0471)	(0.0507)	(0.0514)	(0.0510)	(0.0522)
Border region (1=yes)		0.191***	0.1531**	0.155***	0.170***	0.155***
		(0.0496)	(0.0606)	(0.0559)	(0.0554)	(0.0570)
Mean elevation		0.000184	0.0003	0.000310*	0.000322*	0.000320*
		(0.000158)	(0.0003)	(0.000168)	(0.000167)	(0.000165)
Terrain ruggedness		-0.000439	-0.0004	-0.000415	-0.000280	-0.000416
		(0.000471)	(0.0005)	(0.000480)	(0.000504)	(0.000484)
Soil suitability		-5.80e-06	0.0003	-0.000571	0.00235	-0.000711
		(0.00243)	(0.0034)	(0.00233)	(0.00240)	(0.00237)
		-0.0204	-0.0091	-0.000575	-0.00231	0.00221
Coastal region (1=yes=		(0.0731)	(0.0807)	(0.0729)	(0.0799)	(0.0754)
Number of Celtic		-0.00677	-0.0101	-0.000560	6.58e-05	-0.000296
Oppida		(0.00521)	(0.0063)	(0.00561)	(0.00551)	(0.00588)
Mean sunshine duration		-0.000583	0.0002	-0.000490	-0.000272	-0.000491
		(0.000427)	(0.0004)	(0.000419)	(0.000435)	(0.000426)
Mean temperature		0.0169	0.0498	0.0247	0.0480	0.0248
		(0.0315)	(0.0341)	(0.0280)	(0.0317)	(0.0280)
Hanseatic League		0.0627	0.0457	0.0593	0.0690	0.0580
		(0.0715)	(0.0739)	(0.0738)	(0.0753)	(0.0754)
Number of plague		0.00586**	0.0063**	0.00516*	0.00483*	0.00519*
outbreaks		(0.00239)	(0.0025)	(0.00286)	(0.00255)	(0.00290)
Carboniferous rock		-0.0660	-0.0608	-0.0489	-0.0626	-0.0434
strata		(0.0644)	(0.0884)	(0.0517)	(0.0682)	(0.0576)
Federal State Dummies	No	No	Yes**	No	No	No
R^2	0.1880	0.429	0.5078	0.423	0.351	0.423

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models. Stars after the “Yes” indicate the level of joint statistical significance of the Federal State dummies.

Table A5: Socioeconomic outcomes and Roman legacy—including Federal State fixed effects

Dependent Variable	(1) Life satisfaction	(2) Health satisfaction	(3) Life expectancy	(4) ln(patents)	(5) Start-up rate
Roman (1=yes)	0.190**	0.110	0.475*	0.3409*	8.5710***
	(0.0852)	(0.0927)	(0.254)	(0.1829)	(2.2180)
Intersects major river (1=yes)	-0.105	-0.0288	-0.127	-0.2972*	-1.0390
	(0.0663)	(0.0617)	(0.179)	(0.1707)	(1.6399)
Border region (1=yes)	0.0497	0.0365	0.180	0.3632**	1.9123
	(0.0801)	(0.0760)	(0.185)	(0.1640)	(1.8736)
Mean elevation	0.0002	0.0001	0.00105	0.0018***	0.0024
	(0.0004)	(0.0003)	(0.0008)	(0.0007)	(0.0076)
Terrain ruggedness	-0.0004	4.64e-05	0.00225	0.0012	-0.0003
	(0.0006)	(0.0005)	(0.0015)	(0.0010)	(0.0135)
Soil suitability	-0.00362	-9.30e-05	0.00713	0.0029	-0.2529**
	(0.0039)	(0.0037)	(0.0098)	(0.0065)	(0.1003)
Coastal region (1=yes)	0.0888	0.0876	-0.0467	0.0375	5.2821*
	(0.125)	(0.106)	(0.322)	(0.2827)	(2.8209)
Number of Celtic Oppida	-0.0010	-0.0087	-0.0142	-0.0377**	-0.2075
	(0.0054)	(0.0073)	(0.0184)	(0.0169)	(0.2214)
Mean sunshine duration	0.0001	0.0007	-0.0007	0.0006	-0.0303**
	(0.0008)	(0.0007)	(0.0017)	(0.0012)	(0.0142)
Mean temperature	0.00691	-0.0174	0.205*	0.2600***	0.5938
	(0.0551)	(0.0473)	(0.120)	(0.0955)	(1.0278)
Hanseatic League	0.0521	0.0203	-0.0425	-0.0988	-1.6811
	(0.0959)	(0.0917)	(0.287)	(0.1933)	(2.386)
Number of plague outbreaks	-0.0006	-0.0004	0.0058	0.0095	0.2269***
	(0.003)	(0.003)	(0.0082)	(0.0065)	(0.0674)
Carboniferous rock strata	0.0318	0.0406	-0.492	-0.0394	1.1526
	(0.138)	(0.127)	(0.352)	(0.2277)	(2.6001)
Federal State Dummies	Yes***	Yes***	Yes	Yes***	Yes**
R^2	0.435	0.359	0.555	0.668	0.41

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models. Stars after the "Yes" indicate the level of joint statistical significance of the Federal State dummies.

Table A6: Personality traits, socioeconomic outcomes and Roman legacy—including Federal State Dummies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Neuroticism	Conscientiousness	Entrepreneurial personality	Life satisfaction	Life expectancy	ln(patents)	Start-up rate
Panel A: Roman road density							
Roman road density	-0.874**	0.0370	4.953	4.349***	12.53**	8.449***	105.8**
	(0.376)	(0.340)	(3.432)	(1.641)	(5.125)	(2.835)	(52.07)
R^2	0.331	0.234	0.301	0.447	0.575	0.748	0.384
Panel B: Number of Roman markets & mines							
Number of Roman markets & mines	-0.0210***	0.0122**	0.146**	0.0386	0.167	0.0438	2.014
	(0.00606)	(0.00572)	(0.0646)	(0.0317)	(0.114)	(0.0538)	(1.227)
R^2	0.355	0.254	0.321	0.415	0.553	0.731	0.382
Panel C: Roman road density and number of markets & mines							
Roman road density	-0.501	-0.286	2.090	4.278**	10.80**	9.160***	74.95*
	(0.337)	(0.325)	(3.129)	(1.787)	(5.113)	(3.121)	(44.32)
Number of Roman markets & mines	-0.0168***	0.0146**	0.129*	0.00320	0.0777	-0.0320	1.393
	(0.00584)	(0.00591)	(0.0684)	(0.0308)	(0.114)	(0.0529)	(1.196)
R^2	0.367	0.257	0.323	0.447	0.579	0.749	0.405
Number of observations	96	96	96	96	96	93	96
Federal State Dummies	Yes***	Yes	Yes*	Yes***	Yes*	Yes***	Yes***
Controls included	Yes	Yes*	Yes**	Yes	Yes***	Yes***	Yes***

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. Controls are identical to the ones included in Tables 2 and 4. Significance stars after the “Yes” indicate the lowest level of joint significance of the control variables and Federal State dummies.

Table A7: Using alternative innovation and entrepreneurship outcomes

Dependent Variable	(1) High-tech Start-up rate	(2) Share R&D employees	(3) High-tech Start-up rate	(4) Share R&D employees
Roman (1=yes)	0.8739***	0.7042***	0.8863***	0.7420**
	(0.2138)	(0.2534)	(0.2713)	(0.2968)
Intersects major river (1=yes)	-0.1152	-0.2334	-0.1357	-0.2319
	(0.1848)	(0.1689)	(0.2028)	(0.1897)
Border regions (1=yes)	0.2777	0.3641	0.2570	0.3414
	(0.1675)	(0.2219)	(0.2126)	(0.2476)
Mean elevation	0.0010	-0.0004	0.0016*	-0.0001
	(0.0006)	(0.0007)	(0.0009)	(0.0009)
Terrain ruggedness	-0.0000	0.0017	-0.0003	0.0016
	(0.0015)	(0.0019)	(0.0017)	(0.0020)
Soil suitability	-0.0228**	0.0108	-0.0205*	0.0169*
	(0.0101)	(0.0069)	(0.0119)	(0.0100)
Coastal region (1=yes)	0.2688	-0.1083	0.3956	-0.0415
	(0.2372)	(0.2132)	(0.2862)	(0.2495)
Number of Celtic Oppida	-0.0462***	-0.0687***	-0.0508**	-0.0812***
	(0.0157)	(0.0150)	(0.0200)	(0.0207)
Mean sunshine duration	-0.0016	0.0001	-0.0007	-0.0001
	(0.0016)	(0.0015)	(0.0017)	(0.0017)
Mean temperature	0.1072	0.1651*	0.1689	0.1362
	(0.0892)	(0.0890)	(0.1172)	(0.1141)
Hanseatic League	-0.0804	-0.0295	-0.0707	-0.0878
	(0.2063)	(0.1762)	(0.2387)	(0.2032)
Number of plague outbreaks	0.0280***	0.0258***	0.0296***	0.0301***
	(0.0078)	(0.0076)	(0.0089)	(0.0090)
Carboniferous rock strata	-0.0699	0.0228	0.0712	-0.0408
	(0.1716)	(0.2148)	(0.2798)	(0.3086)
Federal State Dummies	No	No	Yes	Yes
R^2	0.386	0.469	0.431	0.494

Notes: Ordinary least squares regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. The number of observations (regions) is 96 in all models. Stars after the "Yes" indicate the lowest level of joint statistical significance of the Federal State dummies.

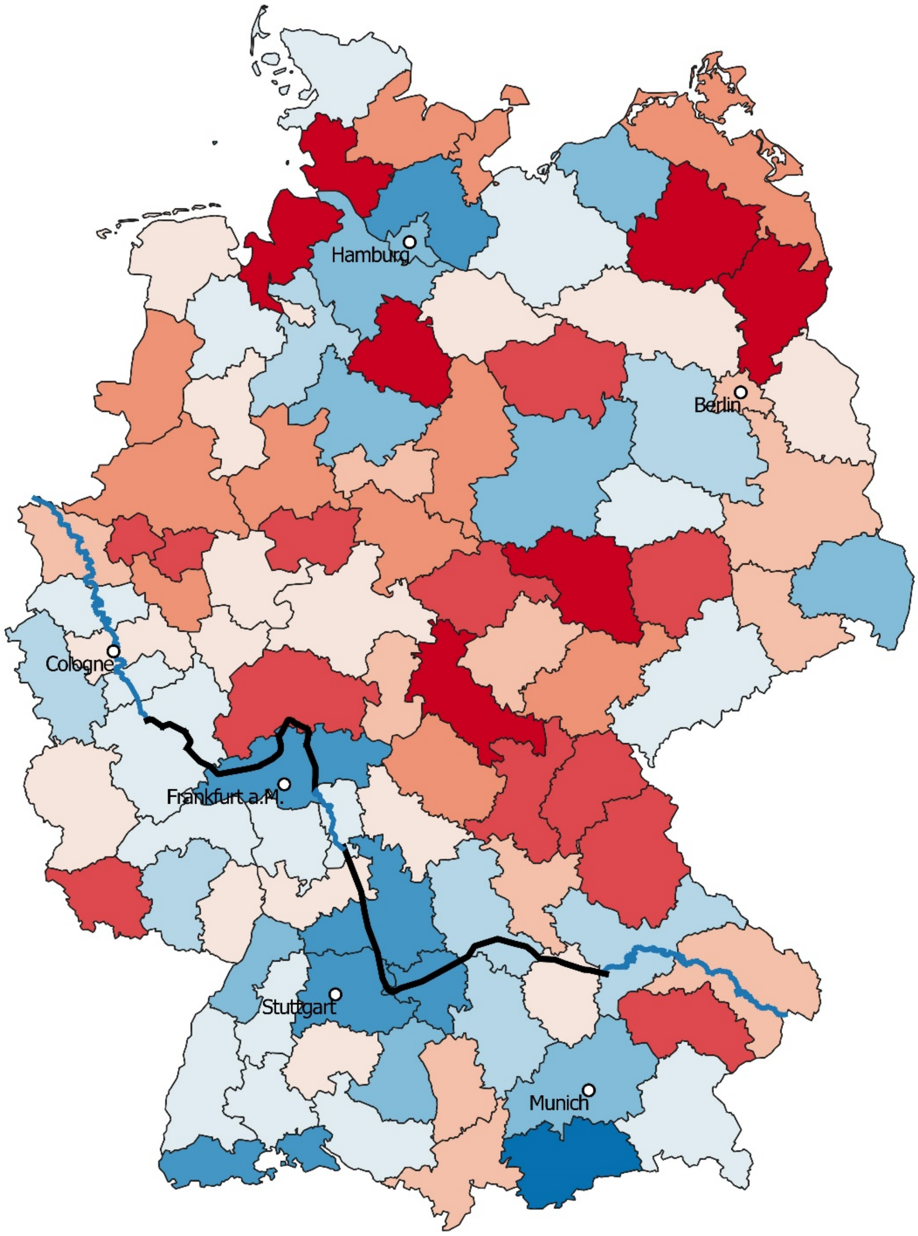

Figure A1: Regional variation of neuroticism and the Limes

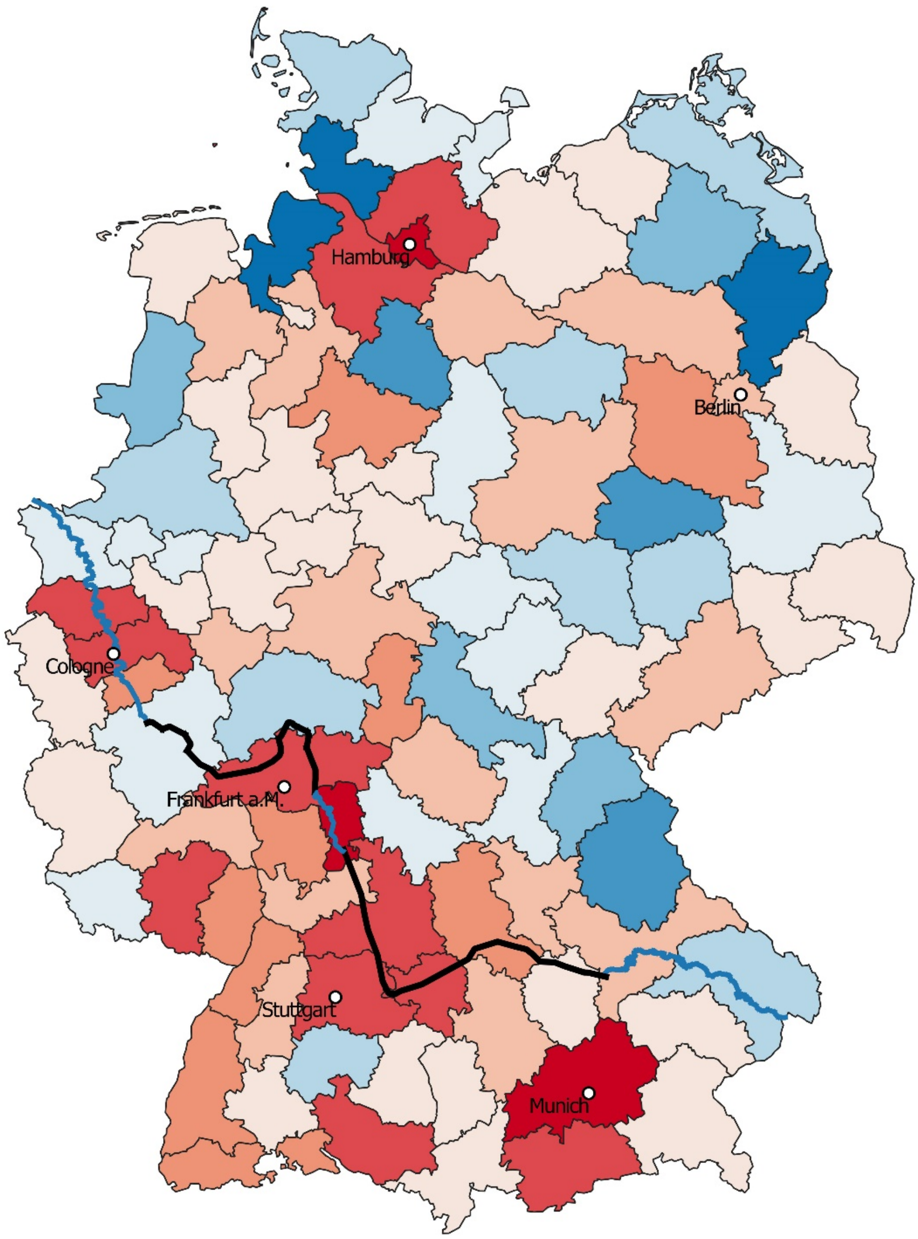

Figure A2: Regional variation of the entrepreneurial personality profile and the Limes

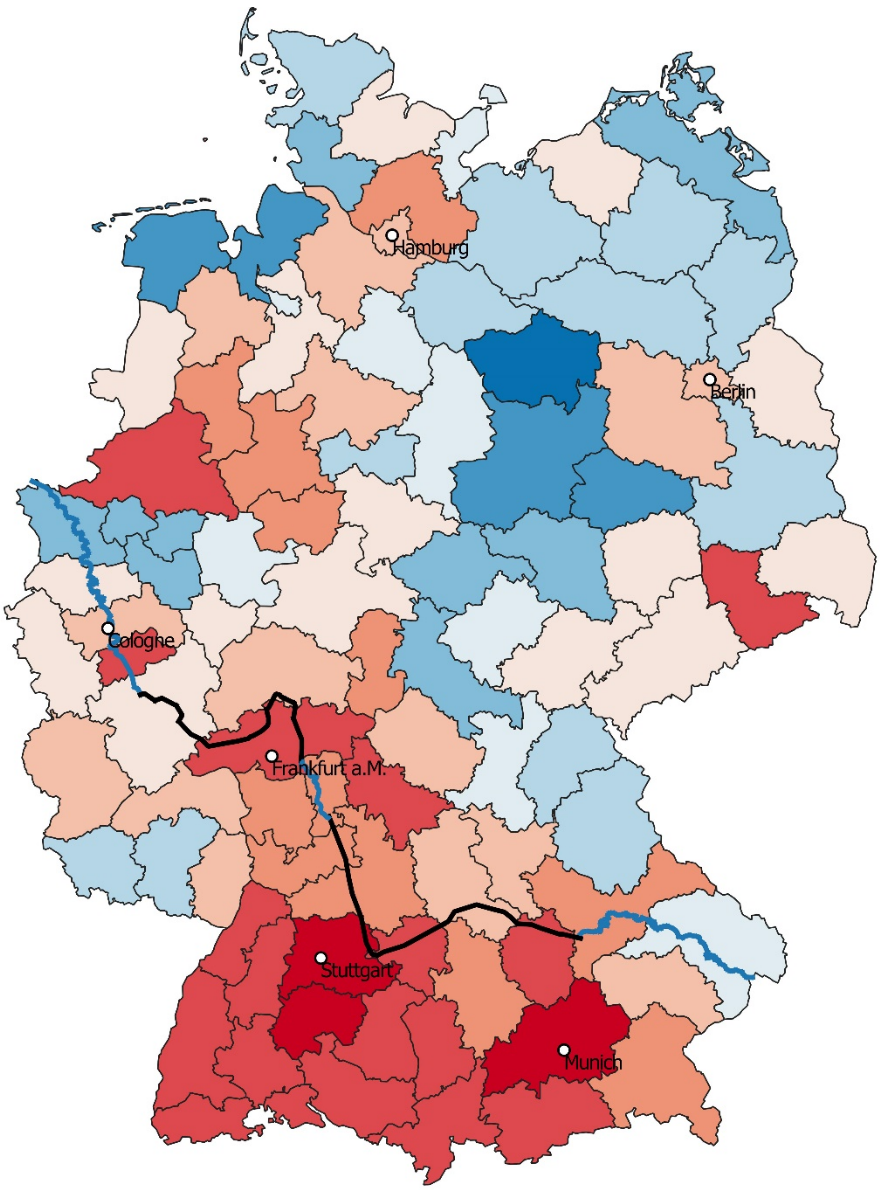

Figure A3: Regional variation of life expectancy and the Limes

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